Maternal nutrition during lactation

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Literature review current through: Jun 2021. | **This topic last updated:** Jun 26, 2020.

INTRODUCTION

A mother's capacity to produce milk of sufficient quantity and quality to support infant growth is resilient and remarkably resistant to nutritional deprivation. However, milk production normally affects maternal body composition and nutritional status, and lactating women have increased nutrient demands.

The changes in maternal nutritional status during lactation, effect of maternal nutrition on milk volume and composition, and nutrient requirements of lactating women are reviewed here. Additional aspects of breastfeeding are discussed separately:

- (See "Initiation of breastfeeding".)
- (See "Common problems of breastfeeding and weaning".)
- (See "Breastfeeding: Parental education and support".)
- (See "Postpartum contraception: Counseling and methods", section on 'Impact of contraception on breastfeeding'.)

EFFECTS OF LACTATION ON THE MOTHER

Lactation is supported partially by mobilization of tissue stores. This, in turn, affects maternal weight and nutritional status.

- **Body weight** – Postpartum weight changes in lactating women are highly variable [1]. Mild, gradual weight loss typically occurs during the first six months postpartum. Excessive weight gain during pregnancy is the most consistent and strongest predictor of

postpartum weight change in most studies [1,2]. Other factors that contribute to weight loss after pregnancy include prepregnancy weight, age, parity, race, smoking, exercise, and return to work outside of the home. (See "Overview of the postpartum period: Disorders and complications", section on 'Postpartum weight retention'.)

Data are conflicting on the effect of breastfeeding on postpartum weight changes. Most studies indicate that lactation has little effect [3-8]. In some reports, weight loss was less in lactating than nonlactating women [2,9-11], whereas other studies report more weight loss in lactating women than nonlactating women [12-15]. A systematic review found little or no association between breastfeeding and weight change, although this seemed to depend on the measurement time points and breastfeeding intensity [16]. However, four out of five studies of high methodologic quality demonstrated a positive association between breastfeeding and weight loss.

- **Lean body mass** – Although some women may lose weight while breastfeeding, the lean body mass of well-nourished women is preserved during the first six months of lactation [17]. This is thought to be due to an adaptive response of protein metabolism when dietary protein is restricted, so that body protein degradation is reduced more than synthesis [18].

- **Vitamins** – Fat-soluble and water-soluble vitamins are secreted into milk. Therefore, the dietary requirement for most vitamins is increased during lactation. A chronically deficient diet will deplete maternal stores of some vitamins. For women consuming a balanced diet, the increased nutrient requirements can be met by the overall increase in food intake. For some restrictive diets, dietary supplements may be necessary. (See 'Vitamins and minerals' below.)

- **Bone mineral loss** – Bone mineral content declines during lactation, and compensatory remineralization occurs after weaning and resumption of menses [19-22]. Changes in calcium, phosphorus, and magnesium homeostasis are independent of maternal dietary intake. Lactation is associated with bone reabsorption, in part due to relatively low estradiol concentrations. A systematic review showed that this bone loss is transient, with recovery depending on the return of menstruation and weaning [23].

  Breastfeeding does not increase the risk of bone fractures in the long term. A systematic review that included 11 studies with more than 100,000 women concluded that there is no evidence of an association between breastfeeding and risk of hip, vertebral, or forearm fractures [24].

DETERMINANTS OF MILK VOLUME

Healthy, exclusively breastfeeding women produce approximately 750 to 800 mL per day of milk when lactation is fully established [25]. However, milk volume varies among individuals and can exceed 2000 mL per day in women with hyperlactation or those nursing twins or triplets.

Milk volume is low during the first two days postpartum, increases markedly on days 3 and 4, and then gradually increases to levels seen in full lactation [26]. Milk volume typically decreases later in lactation (eg, beyond six months postpartum), primarily because of weaning. In a cohort of healthy infants, the average (range) of breast milk volumes at 6, 9, and 12 months postpartum were 769 (335 to 1144), 637 (205 to 1185), and 445 (27 to 1154) mL per day, respectively [25]. The wide range of milk volume during late lactation reflects differences in the timing and rate of weaning.

Infant demand — Milk production is determined mostly by infant demand rather than maternal lactation capacity [27]. This is illustrated by the ability of mothers to successfully breastfeed twins or triplets [28]. The infant's demand depends, in turn, on age and rate of weight gain, as well as any medical disorders that affect the infant's metabolic needs or ability to feed efficiently [26,29-31]. Healthy infants who are fed on cue tend to stimulate normal milk volumes and achieve good growth despite individual variation in intervals between feeding [32]. The addition of milk substitutes or solid foods reduces infant demand for breast milk and thus reduces milk production [33,34].

Maternal nutrition — Mild or moderate variations in maternal diet, energy balance, and aerobic exercise generally do not affect milk production [30,35-37].

- Dieting – Mild or moderate reductions in maternal energy intake appear to have a limited effect on milk volume [35,38]. In one study, dietary restriction to 1500 kcal per day for one week did not reduce milk production [39]. Similarly, moderate weight loss with or without exercise does not adversely affect lactation [40-42]. In one study, lactating women were randomly assigned to an 11-day program of diet, diet plus exercise, or control at 12 weeks postpartum [41]. Weight loss averaged 1.9, 1.6, and 0.2 kg in the three groups, respectively, while milk volume and composition and infant weight gain were similar during the short study period.

  Longer periods of dieting are also well tolerated. In one report, 22 of 33 women who completed a 10-week weight reduction program lost an average of 5 kg [40]. Daily milk production was similar at baseline and at 10 weeks (759 versus 802 mL), and infants gained an average of 21 gm per day. In another study, overweight lactating women were randomly

assigned to reduce energy intake by 500 kcal per day and exercise for 45 minutes four times per week or to maintain their usual diet and limit exercise [43]. Women in the diet and exercise group lost more weight (4.8 versus 0.8 kg) and fat mass (4 versus 0.3 kg) than controls. Infant weight gain was similar, although the statistical power to detect a difference in weight gain was limited [42].

- Severe energy restriction – More extreme nutritional deprivation may have substantial effects on milk volume. In the study cited above, daily milk volume decreased 15 percent when fewer than 1500 kcal per day were consumed [39]. Similarly, some studies of low-income women in resource-limited countries report milk volumes as low as 525 mL/day, while other women produce milk volumes over 800 mL/day, which is similar to average milk volumes in women in resource-rich countries [38,44-50].

Other factors — Other factors that decrease milk volume include incomplete breast emptying and infrequent milk expression [51], as well as maternal smoking, stress, anxiety, fatigue, and illness [52-55]. In addition, use of combined estrogen/progesterone oral contraceptives (COCs) moderately reduces milk volume. In one report that followed lactating women from 6 to 24 weeks postpartum, milk volume decreased by 42 percent in women using COCs, 12 percent in those using progestin-only contraceptives, and 6 percent in women taking no hormonal contraceptives [56]. Nonetheless, infant growth was similar, perhaps because more prolonged or intense feeding periods or supplementary feedings compensated for the reduced milk volume. A systematic review found moderate quality evidence for an effect of COCs on milk volume and overall inconsistent results for other types of hormonal contraceptives [57]. Because there is no firm evidence that hormonal contraceptives interfere with breastfeeding success, an individualized approach seems appropriate [58]. The American College of Obstetrics and Gynecology recommends that "obstetric care providers should discuss any concerns within the context of each woman's desire to breastfeed and her risk of unplanned pregnancy, so that she can make an autonomous and informed decision" [59]. (See "Postpartum contraception: Counseling and methods", section on 'Impact of contraception on breastfeeding'.)

Skin-to-skin contact between a mother and her preterm infant in the newborn intensive care unit may increase milk production [60,61]. (See "Breast milk expression for the preterm infant", section on 'Skin-to-skin contact'.)

EFFECTS OF THE MATERNAL DIET ON MILK QUALITY

Lactation requires additional energy and nutrients from the diet. Milk quality is usually sufficient to support infant growth, even when the mother's dietary supply of energy and

nutrients is limited [25]. However, a chronically deficient diet can deplete maternal nutrient stores and adversely affect milk composition.

- **Protein content** – Maternal diet typically does not affect the quantity or quality of milk protein, even in malnourished populations [62-64].

- **Fat content** – The proportion of dietary fat in the maternal diet has minimal effects on the **quantity** of fatty acids in human milk; however, the type of fat consumed by the mother influences the fatty acid composition of the milk [65,66]. As an example, maternal consumption of omega-3 long-chain polyunsaturated fatty acids (n-3 LCPUFA), which include docosahexaenoic acid (DHA), affects concentrations of these fatty acids in breast milk. The relevance of n-3 LCPUFA to infant brain development has been suggested but not confirmed in most clinical studies [67]. (See "Long-chain polyunsaturated fatty acids (LCPUFA) for preterm and term infants".)

  Despite lack of definitive evidence, the American Academy of Pediatrics recommends that breastfeeding women take in 200 to 300 mg of n-3 LCPUFA (eg, DHA) to guarantee a sufficient concentration of preformed DHA in the milk [68]. One to two servings of fish per week is adequate to supply this amount of DHA. (See 'Fish intake' below.)

  Other variations in the fatty acid content of breast milk may have little clinical relevance. For example, mothers on a low-fat diet produce breast milk with a slightly higher fraction of medium-chain fatty acids compared with mothers consuming a high-fat diet [69]. Consumption of partially hydrogenated fats and oils also influences the fatty acid composition of milk. As an example, linoleic acid concentration was higher in milk from vegan mothers than omnivore controls [70]. However, diet does not appear to affect the cholesterol and phospholipid content of human milk [65].

- **Fat-soluble vitamins** – The concentration of fat-soluble vitamins in milk is reduced in maternal vitamin deficiency and increases following supplementation.

  The vitamin D content of breast milk is constitutively low [68,71,72], and it is even lower in mothers with dark skin or other causes of maternal vitamin D deficiency [73]. As a result, all infants require vitamin D supplementation to prevent rickets, and this is particularly important for those whose mothers have vitamin D deficiency. An alternate but rarely used strategy is to administer moderately high doses of vitamin D to the lactating mother (4000 to 6400 international units daily, which is approximately 10 times the recommended intake), which increases the vitamin D content of the breast milk to levels that meet the infant's needs. However, higher doses of vitamin D should be avoided; in one report, ergocalciferol 2500 mcg (100,000 international units daily, which is >150 times the

recommended intake) resulted in toxic levels in milk [74]. (See "Vitamin D insufficiency and deficiency in children and adolescents", section on 'Maternal vitamin D deficiency' and "Vitamin D insufficiency and deficiency in children and adolescents", section on 'Prevention in the perinatal period and in infants'.)

Vitamin K concentration in breast milk varies with maternal dietary intake but is generally low [75]. As a result, infants are at risk for vitamin K-deficient bleeding, which can be prevented by routine administration of vitamin K at birth. (See "Overview of vitamin K", section on 'Prevention'.)

Vitamin A content in breast milk also varies with the maternal diet [76,77]. Clinically important vitamin A deficiency is rare in infants in resource-rich countries, in the absence of an underlying malabsorptive disease. In parts of the world in which vitamin A deficiency is endemic, routine vitamin A supplementation is no longer recommended for lactating women, neonates, or infants up to six months of age. This is because studies of vitamin A supplementation have shown no consistent health benefits and may have side effects in young infants. High-dose vitamin A supplementation is recommended in infants and children 6 to 59 months of age in settings where vitamin A deficiency is a public health problem. (See "Overview of vitamin A", section on 'Universal periodic distribution'.)

- **Water-soluble vitamins** – The concentration of water-soluble vitamins in milk also depends upon maternal diet and is reduced with vitamin deficiency. However, the concentration of water-soluble vitamins in milk is regulated so that it does not exceed an upper threshold, even if the mother's intake of these vitamins is very high [78-80]. Vitamin C and thiamine (vitamin B1) concentrations, for example, remain below approximately 160 mg/L and 200 mcg/L, respectively [78-80].

  Vitamin content in milk is reduced in vitamin-deficient states and responds to supplementation [77]. In women with thiamine deficiency (beriberi), for example, the thiamine content of their milk is low. Vitamin B6 (pyridoxine) concentration in milk also responds rapidly to changes in maternal intake [81].

  Folate is preferentially secreted into milk at the expense of maternal reserves. However, milk concentrations are reduced in severe folate deficiency and increase after folate supplementation [82]. Vitamin B12 content in milk is also reduced with deficiency that may occur in vegans, malnourished women, women with latent pernicious anemia [83], and those who have undergone gastric bypass surgery [84]. There are case reports of irreversible developmental delay in exclusively breastfed infants of vitamin B12-deficient

mothers [85]. It may be advisable to monitor maternal vitamin B12 status during lactation, with oral or parenteral supplementation for mothers with vitamin B12 deficiency.

- **Mineral content** – The levels of most inorganic components of human milk are independent of maternal diet or serum concentrations, although intake of some trace minerals affects milk levels. Concentrations of calcium, phosphorus, and magnesium in milk are independent of maternal serum levels and are not substantially influenced by variations in dietary intake [86]. Iron, copper, and zinc levels in human milk are also independent of maternal nutrient status [87-90].

  However, breast milk content for some other minerals is associated with maternal nutrient status: In one study, selenium concentration in milk correlated with maternal plasma concentration, which was influenced by diet [91]. Breast milk iodine concentration also depends upon dietary intake [92]. The primary risk factors for iodine deficiency are a diet without iodized salt or dairy products. Dietary iodine deficiency may also be exacerbated by smoking; iron deficiency; and consumption of large amounts of foods that interfere with the production of thyroid hormones, known as goitrogens, including Brussels sprouts, kale, cabbage, cauliflower, and broccoli [93]. Either iodine deficiency or iodine excess can cause neonatal hypothyroidism [94]. (See "Clinical features and detection of congenital hypothyroidism", section on 'Transient congenital hypothyroidism'.)

NUTRIENT REQUIREMENTS

Nutritional requirements to support lactation are high, and the requirements for many components are greater in lactating women than in those who are pregnant or in the nonpregnant state (table 1) [95]. For example, requirements for energy; protein; vitamins A, C, E, B6, and B12; folate; niacin; riboflavin; thiamine; and the minerals iodine, selenium, and zinc are increased in lactating women. In contrast, requirements for vitamins D and K and the minerals calcium, fluoride, magnesium, and phosphorus do not differ between lactating and nonlactating states. The requirement for iron is lower during lactation because of lactational amenorrhea. For women consuming a balanced diet, the increased nutrient requirements can be met by the overall increase in food intake. For some restrictive diets, dietary supplements may be necessary.

Energy — The estimated energy (caloric) requirement during lactation is based on maternal age, weight, height, and physical activity level, as outlined in the table (table 2) [96], **plus** the following additional energy requirements for milk synthesis:

- From 0 through 6 months postpartum – **330 kcal per day** more than nonlactating women. This is based on the energy cost of exclusive breastfeeding of 500 kcal/day (from an average milk production of 780 mL per day, with an average energy content of 67 kcal/100 mL) [97]. In well-nourished women, the energy cost of lactation is subsidized by mobilization of tissue stores (approximately 170 kcal per day) due to gradual loss of the weight gained during pregnancy during the first six months postpartum.

- From 7 through 12 months of postpartum – **400 kcal per day** more than nonlactating women. The energy cost of lactation is based on an average milk production of 600 mL per day and the same energy content [97]. The calculation for this timeframe does not include a subsidy from mobilization of tissue stores, because it assumes that the mother's weight is stable.

For women with healthy body mass indexes and average heights, this amounts to total energy needs ranging from 2130 to 2730 kcal/day for the first six months of lactation and 2200 to 2800 kcal/day thereafter, depending on maternal age, weight, height, and activity level (table 2). A woman's energy need also varies with the timing and rate of weaning.

Protein — The recommended dietary allowance (RDA) for protein for the first six months of lactation is 71 grams per day, which is 25 grams more than the requirement for nonlactating women [97]. This RDA is based upon the volume of milk (780 mL per day), the average protein content of milk (1 g/100 mL), and an efficiency of utilization of dietary protein for milk synthesis of 47 percent.

Vitamins and minerals — Recommended intakes for vitamins and minerals during pregnancy and lactation are outlined in the table (table 1) [86,98,99].

- **Fat-soluble vitamins** – The RDAs for vitamins A and E represent an increase requirement during lactation compared with nonlactating women to compensate for the vitamins secreted into milk. After six months of lactation, the requirement reverts to that of nonlactating women.

  The maternal requirements for vitamins D and K are not increased during lactation. However, breast milk does not supply sufficient D and K to meet the infant's needs, and infants require supplementation. Vitamin K supplementation is routinely given to the infant at birth (see "Overview of vitamin K", section on 'Prevention'). For the breastfed infant, vitamin D can be provided as supplements or the mother can be supplemented with large doses of vitamin D. (See "Vitamin D insufficiency and deficiency in children and adolescents", section on 'Prevention in the perinatal period and in infants'.)

- **Water-soluble vitamins** – The RDAs for vitamin C and the B vitamins for lactating women exceed those of nonlactating women (table 3) [99,100]. These requirements account for the amount of nutrient secreted into milk and allow for metabolic inefficiencies and individual variation.

- **Calcium, phosphorus, and magnesium** – The RDA for calcium during lactation is 1000 mg daily for women 19 years and older and 1300 mg daily for adolescents [86]. These requirements are the same as for nonlactating women, although approximately 200 mg per day of calcium is secreted in milk.

  The RDA for calcium is not increased during lactation, because lactation-induced loss in bone mass is not prevented by increased calcium intake and because the loss in bone mass is recovered after weaning [86]. As an example, in one report, loss of bone mass during lactation was similar with calcium supplementation (1 g per day) and placebo [101-103]. Recovery of bone loss occurred with resumption of menses and weaning [104-106]. Similarly, another randomized trial among postpartum women found no difference in bone mineral density with calcium supplementation [107]. Moreover, the calcium content of the breast milk is not affected by maternal calcium intake, because increased bone mobilization and decreased urinary excretion provide the calcium needed for milk production [19,108]. Intestinal calcium absorption does not appear to increase [104,109].

  Increased bone resorption and decreased urinary excretion of phosphorus and magnesium are also independent of dietary intake during lactation. Therefore, the dietary recommendations for phosphorus and magnesium are the same as for nonlactating women [110].

- **Trace minerals**

  - **Iron** – The RDA for iron during lactation is 9 mg daily for women 19 years and older and 10 mg daily for adolescents [98]. This recommendation is less than the RDA for nonlactating women (18 mg daily) and adolescents (15 mg daily) because of lactation-induced amenorrhea, which reduces iron loss. Thus, postpartum use of a prenatal multivitamin (which provides approximately 30 mg daily of iron) is not necessary for a lactating woman, unless she is known to be iron deficient. A multivitamin that contains less than 30 mg of iron may have fewer gastrointestinal side effects and be better tolerated.

  - **Iodine** – In order to support proper infant growth and neurologic development, the RDA for iodine during lactation (290 mcg per day) is higher than pregnancy (220 mcg per day) and prior to pregnancy (150 mcg per day). Several societies recommend that

breastfeeding women take a daily multivitamin or prenatal supplement every day containing 150 mcg of iodine [111].

- **Zinc and** selenium – The RDAs for these minerals are moderately higher during lactation than for nonlactating nonpregnant women to compensate for their secretion into the breast milk [98].

Fish intake — Fish and shellfish contribute high-quality protein and other essential nutrients to the diet. Fish consumption by breastfeeding mothers has been suggested to be beneficial to the infant because fish contain large amounts of omega-3 long-chain polyunsaturated fatty acids (n-3 LCPUFA), including docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), which are important in brain development. However, available data are insufficient to demonstrate an association between maternal n-3 fatty acid intake during lactation and subsequent cognitive function in offspring. (See "Long-chain polyunsaturated fatty acids (LCPUFA) for preterm and term infants".)

A potential disadvantage of fish intake is exposure to mercury. Nearly all fish and shellfish contain traces of mercury. For most people, the risk from mercury by eating fish and shellfish is not a health concern. Consumption of certain fish and shellfish by breastfeeding women may pose an increased risk to the breastfed infant's developing nervous system since both inorganic and organic mercury are transferred from maternal serum to human milk. The mercury concentrations in human milk are highly variable and tend to decline between colostrum and mature milk [112]. Mercury intake can be minimized by avoiding the intake of predatory fish (eg, pike, marlin, mackerel, tilefish, swordfish).

In considering the potential benefit of n-3 LCPUFA versus the risks of mercury exposure, the American Academy of Pediatrics concluded that the "possible risk from intake of excessive mercury or other contaminants is offset by the neurobehavioral benefits of an adequate DHA intake" [68]. However, some pregnant and postpartum women may have concerns about fish safety, leading them to omit fish consumption altogether to avoid the possibility of mercury exposure [113,114]. Therefore, it is important to provide patients with guidance on choosing safe fish to consume during pregnancy and lactation.

The US Food and Drug Administration and the Environmental Protection Agency issued the following guidelines for fish intake for pregnant women, breastfeeding mothers, and young children [115]. These recommendations allow the mother and her infant to receive some of the potential benefits of eating fish and shellfish, while limiting mercury intake.

- Breastfeeding mothers should eat 8 to 12 ounces a week (two average servings) of fish and shellfish that have lower concentrations of mercury. They include canned light tuna,

salmon, pollock, catfish, and shrimp. Albacore (white) tuna has more mercury than canned light tuna; therefore, consumption of albacore tuna should be limited to 6 ounces (one average meal) per week.

- Breastfeeding mothers should not eat shark, swordfish, king mackerel, or tilefish, because they contain high concentrations of mercury (table 4).

- Check local advisories about the safety of fish caught by family and friends in local lakes, rivers, and coastal areas. If no advice is available, breastfeeding mothers may eat up to 6 ounces (one average meal) per week of fish caught from local waters but should not consume any other fish during that week.

Potential benefits, risks, and strategies for fish consumption during pregnancy are discussed in detail in a separate topic review. (See "Fish consumption and marine omega-3 fatty acid supplementation in pregnancy".)

COUNSELING ABOUT COMMON CONCERNS

Special diets — Women with specific dietary needs may have questions about their diets while breastfeeding:

- Dieting for weight loss – After lactation is established, overweight/obese women may restrict their energy intake by 500 kcal/day and undertake aerobic exercise four days/week to promote 0.5 kg/week weight loss without compromising their milk supply [116]. Exercise alone, without dieting, does not seem to promote postpartum weight loss. A systematic review concluded that diet or diet plus exercise are effective weight loss strategies for postpartum lactating and nonlactating women [117].

  Rarely, a syndrome of "lactation ketoacidosis" has been reported in lactating women, typically associated with restrictive dieting and especially with low carbohydrate intake [118,119]. Presenting symptoms and signs include nausea, vomiting, and abdominal pain with a high-anion gap ketoacidosis. It is thought to be a form of fasting ketosis, accelerated by the increased energy needs of a lactating women. (See "Fasting ketosis and alcoholic ketoacidosis", section on 'Fasting ketosis'.)

- Vegetarian diets – Lactating women on vegetarian diets should be cognizant of the potential risk for mineral, protein, and vitamin deficiencies. Depending on the degree of dietary restriction (eg, ovo- or lactovegetarian), calcium, vitamin D, and vitamin B12 supplements may be required to meet recommended intakes for these nutrients.

- Vegan diet – Women who are healthy but who do **not** eat meat, chicken, fish, or dairy products need to take a vitamin supplement that contains vitamin B12. Most commercially available multivitamins contain an adequate dose of B12.

- Fasting – Short-term fasting does not diminish milk supply but may have a minor effect on milk composition [120,121]. Metabolic adaptations during short-term fasting safeguard milk production. Longer-term fasting might adversely affect the nutritional status of lactating women. Therefore, lactating women might be excused from fasting during Ramadan for health reasons [121].

- Food avoidance to prevent atopic disease in offspring – Food avoidance by breastfeeding mothers is not recommended as a means of preventing allergy, even in high-risk children [122]. Although both avoidance and ingestion of specific antigens such as peanuts, milk, and eggs during lactation have been hypothesized to reduce the frequency of atopic disease in offspring, the bulk of evidence does not support either approach [123]. (See "Primary prevention of allergic disease: Maternal diet in pregnancy and lactation".)

- Women who have had bariatric surgery – Lactation is usually not adversely affected by bariatric surgery, and breastfeeding should be encouraged. Milk composition of women who have undergone bariatric surgery was shown to be adequate in energy, macronutrients, and vitamin A [124]. Women who breastfeed should continue their vitamin and mineral supplements and should be monitored for nutrient deficiencies, such as vitamin B12 deficiency. (See "Fertility and pregnancy after bariatric surgery", section on 'Postpartum'.)

Alcohol — A small percentage of alcohol is transferred into breast milk. The amount of alcohol considered to be "safe" while breastfeeding is controversial. We suggest that a breastfeeding woman avoid exposing the infant to alcohol by waiting to nurse for two hours after a single serving of alcohol (12 ounces of beer, 5 ounces of wine, or 1.5 ounces of 80-proof liquor). If a woman drinks more than this amount, she should refrain from breastfeeding for an additional two hours for each serving of alcohol [125]. It is not necessary to express and discard milk after consuming alcohol, unless the breasts become uncomfortably engorged before enough time has elapsed for the alcohol to leave her system. Heavy alcohol intake can impair judgement and child care abilities and should be avoided, regardless of how the infant is fed. Further details about the pharmacokinetics and effects of alcohol use during lactation are available in the LactMed database [126].

Caffeine — Most breastfeeding women can drink a moderate amount of caffeine without significant effects on their infants. The American Academy of Pediatrics defines a moderate

intake of caffeine as two to three cups of a caffeinated beverage per day [127]. However, some young infants are sensitive to caffeine and become irritable or have difficulty sleeping, even with small amounts of caffeine. An infant's sensitivity to caffeine usually lessens over time because caffeine clearance is initially slow in newborns but rises to adult clearance levels by three to five months.

Nonnutritive sweeteners — Saccharin, sucralose, and acesulfame potassium have been identified in human breast milk at low levels [126,128,129]. Maternal ingestion of typical quantities probably do not cause adverse effects in the infant, although some experts advise against maternal ingestion of large quantities of these substances. Aspartame is not secreted into human breast milk, even when consumed in quantities far exceeding typical amounts. (See "Overview of non-nutritive sweeteners", section on 'Specific health outcomes'.)

Foods to avoid — Breastfeeding women should avoid fish with high concentrations of mercury (table 4). (See 'Fish intake' above.)

Otherwise, there are no restrictions of specific foods for the lactating mother. In particular, unpasteurized dairy products or undercooked meats do not have special health risks for lactating women or their infants.

If the mother or infant has a metabolic disease such as phenylketonuria or glucose-6-phosphate dehydrogenase deficiency, special dietary restrictions will apply. (See "Diagnosis and management of glucose-6-phosphate dehydrogenase (G6PD) deficiency", section on 'Management' and "Overview of phenylketonuria", section on 'Dietary restriction'.)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Breastfeeding and infant nutrition".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5^{th} to 6^{th} grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more

sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topics (see "Patient education: Health and nutrition during breastfeeding (The Basics)")
- Beyond the Basics topics (see "Patient education: Maternal health and nutrition during breastfeeding (Beyond the Basics)")

SUMMARY AND RECOMMENDATIONS

Maternal milk production is dependent upon mobilization of maternal stores and dietary consumption.

- Changes in maternal body composition vary during breastfeeding. Typically, there is a mild gradual weight loss during the first six months postpartum, with preservation of lean body mass. (See 'Effects of lactation on the mother' above.)
- Infant demand is the major factor in determining milk volume. Maternal factors associated with decreased milk volume include maternal stress, anxiety, fatigue, illness, maternal insulin resistance, hormonal oral contraceptives, smoking, and separation from the infant. (See 'Determinants of milk volume' above.)
- Lactation requires additional energy and nutrients in the maternal diet including protein, vitamins A and E, and several other vitamins and minerals (table 1). (See 'Nutrient requirements' above.)
- The recommended intake for calcium and vitamin D by lactating women are the same as for nonlactating women. This is because maternal bone mineral content, which typically declines during lactation and then rebounds after weaning, is not affected by the mother's intake of these nutrients. Breast milk is low in vitamin D, and supplementation to the infant is required. (See 'Effects of lactation on the mother' above and 'Effects of the maternal diet on milk quality' above and 'Vitamins and minerals' above.)

- Fish consumption by breastfeeding women provides omega-3 long-chain polyunsaturated fatty acids (n-3 LCPUFA), which have been proposed to be beneficial for brain development. However, fish consumption also may pose an increased risk to the breastfed infant's developing nervous system since nearly all fish and shellfish contain traces of mercury and mercury is transferred from maternal serum to human milk. We agree with advisories that suggest women who are pregnant or breastfeeding consume two or three servings per week of fish and shellfish that is high in n-3 LCPUFA and low in mercury, such as canned light tuna, salmon, pollock, tilapia, cod, catfish, and shrimp (**Grade 2C**). Shark, swordfish, king mackerel, and tilefish should be avoided because they contain relatively high concentrations of mercury. (See 'Fish intake' above.)

- There are no adverse health effects for the lactating mother or her infant associated with moderate dieting to target gradual weight loss, a balanced vegetarian diet, or short-term fasting. Women consuming a vegan diet or who have undergone bariatric surgery may benefit from nutritional counseling and monitoring to ensure adequate intake of micronutrients, especially vitamin B12. (See 'Special diets' above.)

- Breastfeeding mothers should consume no more than a small amount of alcohol. To minimize transfer of alcohol to the infant, we advise mothers wait at least two hours per serving of alcohol before breastfeeding. Most breastfeeding women can drink a moderate amount of caffeine without significant effects on their infants. (See 'Alcohol' above and 'Caffeine' above.)

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Topic 4960 Version 31.0

GRAPHICS

Recommended dietary allowances, or adequate intakes, and tolerable upper limits for adult pregnant and lactating women

	RDAs		ULs for pregnant and lactating women
	Pregnant women*	Lactating women*	
Fat-soluble vitamins			
Vitamin A	770 mcg	1300 mcg	3000 mcg
Vitamin D	600 international units (15 mcg)	600 international units (15 mcg)	4000 international units (100 mcg)
Vitamin E	15 mg	19 mg	1000 mg
Vitamin K[¶]	90 mcg	90 mcg	ND
Water-soluble vitamins			
Vitamin C	85 mg	120 mg	2000 mg
Thiamin	1.4 mg	1.4 mg	ND
Riboflavin	1.4 mg	1.6 mg	ND
Niacin	18 mg	17 mg	35 mg
Vitamin B6	1.9 mg	2 mg	100 mg
Folate	600 mcg	500 mcg	1000 mcg
Vitamin B12	2.6 mcg	2.8 mcg	ND
Minerals			
Calcium	1000 mg	1000 mg	2500 mg
Phosphorus	700 mg	700 mg	4000 mg
Iron	27 mg	9 mg	45 mg
Zinc	11 mg	12 mg	40 mg
Iodine	220 mcg	290 mcg	1100 mcg
Selenium	60 mcg	70 mcg	400 mcg

RDA: recommended dietary allowance; AI: adequate intake; UL: (tolerable) upper limit; ND: not determinable, due to lack of data of adverse effects and concern with regard to lack of ability to handle excess amounts.

* Females over 18 years old.

¶ The requirement for vitamin K is given as an AI rather than an RDA because there was insufficient scientific evidence to calculate the RDA.

Adapted from: Guidelines for Perinatal Care, sixth edition (2007); and Institute of Medicine Dietary Reference Intakes for Calcium and Vitamin D (2011), which can be accessed via www.nap.edu.

Graphic 60019 Version 9.0

Estimated caloric needs of reproductive-aged women (nonpregnant, nonlactating)

Age (years)	Sedentary* (kcal/day)	Moderately active¶ (kcal/day)	Active∆ (kcal/day)
15 to 18	1800	2000	2400
19 to 25	2000	2200	2400
26 to 30	1800	2000	2400
31 to 50	1800	2000	2200
51 to 55	1600	1800	2200

These estimates are based on the estimated energy requirements equations, using reference heights (average) and reference weights (healthy) for each age group. These estimates apply to women who are not pregnant or breastfeeding.

kcal: kilocalories.
* Sedentary means a lifestyle that includes only the physical activity of independent living.
¶ Moderately active means a lifestyle that includes physical activity equivalent to walking approximately 1.5 to 3 miles per day at 3 to 4 miles per hour, in addition to the activities of independent living.
∆ Active means a lifestyle that includes physical activity equivalent to walking more than 3 miles per day at 3 to 4 miles per hour, in addition to the activities of independent living.

Data from: U.S. Department of Health and Human Services and U.S. Department of Agriculture. 2020–2025 Dietary Guidelines for Americans, 9th Edition, December 2020. Available at: https://www.dietaryguidelines.gov/ (Accessed on January 20, 2021).

Graphic 108793 Version 4.0

Recommended dietary allowances for vitamins during lactation

	RDA for women	Milk secretion	Efficiency	RDA for lactation
Vitamin C	75 mg/d	40 mg/d	85 percent	120 mg/d
Thiamine	1.1 mg/d	0.16 mg/d	0.1 mg/d	1.4 mg/d
Riboflavin	1.1 mg/d	0.3 mg/d	0.1 mg/d	1.6 mg/d
Niacin	14 mg/d	1.4 mg/d	1 mg/d	17 mg/d
Vitamin B6	1.3 mg/d	0.1 mg/d	0.48 mg/d	2 mg/d
Folic acid	400 mcg/d	66 mcg/d	66 mcg/d	500 mcg/d
Vitamin B12	2 mcg/d	0.33 mcg/d		2.8 mcg/d

RDA: recommended dietary allowance.

Data from: Dietary Reference Intakes. The Essential Guide to Nutrient Requirements. Otten JJ, Hellwig JP, Meyers LD (Eds), IoM, Washington, DC 2006.

Graphic 62755 Version 6.0

Mercury levels in commercial fish and shellfish

Species	Mercury concentration (PPM; mean)	Number of samples
Fish and shellfish with highest levels of mercury		
King mackerel	0.730	213
Shark	0.988	351
Swordfish	0.976	618
Tilefish (Gulf of Mexico)	1.450	60
Fish and shellfish with lower levels of mercury¶		
Anchovies	0.043	40
Butterfish	0.058	89
Catfish	0.049	23
Clam*	ND	6
Cod	0.095	39
Crab$^{\Delta}$	0.060	63
Crawfish	0.033	44
Croaker (Atlantic)	0.072	35
Flatfish*◊	0.045	23
Haddock (Atlantic)	0.031	4
Hake	0.014	9
Herring	0.044	38
Jacksmelt	0.108	16
Lobster (spiny)	0.09	9
Mackerel (North Atlantic)	0.050	80
Mackerel (Chub, Pacific)	0.088	30
Mullet	0.046	191
Oyster	0.013	38
Perch (ocean)*	ND	6
Pollock	0.041	62
Salmon (canned)*	ND	23
Salmon (fresh/frozen)*	0.014	34
Sardine	0.016	29
Scallop	0.050	66
Shad (American)	0.065	59
Shrimp*	ND	24
Squid	0.070	200
Tilapia*	0.010	9
Trout (freshwater)	0.072	34
Tuna (canned, light)	0.118	347
Whitefish	0.069	28
Whiting	ND	2

Mercury levels of other fish and shellfish ¶		
Bass (saltwater, black, striped) §	0.219	47
Bass (Chilean)	0.386	40
Bluefish	0.337	52
Buffalofish	0.19	4
Carp	0.14	2
Croaker (white, Pacific)	0.287	15
Grouper (all species)	0.465	43
Halibut	0.252	46
Lobster (Northern/American)	0.310	88
Lobster (species unknown)	0.169	16
Mackerel (Spanish, Gulf of Mexico)	0.454	66
Mackerel (Spaish, South Atlantic)	0.182	43
Marlin*	0.485	16
Monkfish	0.180	81
Orange roughy	0.554	49
Perch (freshwater)	0.14	5
Sablefish	0.220	102
Scorpionfish	0.286	78
Sheepshead	0.128	59
Skate	0.137	56
Snapper	0.189	43
Tilefish (Atlantic)	0.144	32
Tuna (canned, Albacore)	0.353	399
Tuna (fresh/frozen, all)	0.383	228
Tuna (fresh/frozen, Albacore)	0.357	26
Tuna (fresh/frozen, Bigeye)	0.639	13
Tuna (fresh/frozen, Skipjack)	0.205	2
Tuna (fresh/frozen, Yellowfin)	0.325	87
Tuna (fresh/frozen, species unknown)	0.414	100
Weakfish (sea trout)	0.256	39

Mercury was measured as total mercury, except for species (*) in which only methylmercury was analyzed.
Source of data: FDA 1990 to 2004, "National Marine Fisheries Service Survey of Trace Elements in the Fishery Resource" Report 1978, "The Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico" Report 2000.

ND: not determinable, since mercury concentration was below the detection level (<0.01 ppm).
¶ The following species have been removed from the tables: Bass (freshwater) - not commercial; Pickerel - not commercial.
Δ Includes blue, king, snow.
◊ Includes flounder, plaice, sole.
§ Includes sea bass/striped bass/rockfish.

Data from: Mercury levels in commercial fish and Shellfish. US Food and Drug Administration. Available at http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/Seafood/FoodbornePathogensContaminants/Methylmercury/ucm115644.htm. Accessed 1/26/2010.

Graphic 63441 Version 6.0

Contributor Disclosures

Nancy F Butte, PhD Nothing to disclose **Alison Stuebe, MD, MSc** Patent Holder: Couplet Care Bassinet [Inventor]. Grant/Research/Clinical Trial Support: Janssen Research and Development [Perinatal depression]. **Steven A Abrams, MD** Grant/Research/Clinical Trial Support: Perrigo Nutrition [Food insecurity; coronavirus disease 2019]. **Kathleen J Motil, MD, PhD** Consultant/Advisory Boards: Acadia. **Alison G Hoppin, MD** Nothing to disclose

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